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LXIII. On the immediate transmission of calorific rays through diathermal bodies

M. Macedoine Melloni

LXIII. *On the immediate Transmission of Calorific Rays through Diathermal Bodies. By M.* Macedoine Melloni.*

AT the last meeting of the British Association for the Advancement of Science, Mr. H. Hudson and Mr. Powell furnished several communications on radiant caloric †. After having cited some of my experiments on calorific transmission, these ingenious philosophers endeavoured to explain them by hypotheses which in my opinion can no longer be sustained in the present state of science. I wish to direct inquiry to a subject which by its intimate connexion with the fundamental properties of one of the principal agents of nature, appears to me worthy to engage our attention.

For a long time the immediate transmission of terrestrial radiant heat by transparent substances, both solid and liquid, has been denied; and the opinion has become prevalent that we see in experiments of this kind only an effect of the heat absorbed by the body submitted to the calorific radiation. Hence, from the first researches which I undertook upon the immediate transmission of heat, I have endeavoured to render my observations entirely independent of the heating effect proper to the diaphanous plate submitted to experiment; and I succeeded in this by a very simple arrangement, which consists in diminishing as much as possible, in the first instance, the heating effect of the plate, by placing it at a considerable distance from the source, and then in rendering its action upon the thermoscope *wholly insensible*, by removing the instrument to the requisite distance from the plate itself. But in order to experiment under these circumstances, it is clearly necessary to employ an extremely delicate thermoscope, such as well-constructed thermomultipliers otherwise, the feeble rays of heat, direct or transmitted, which arrive from the distance at which the instrument is fixed, would produce no perceptible effect. Further, when any one wishes to make experiments on the transmission of caloric, he may always assure himself that the condition above mentioned is fulfilled. For that I have given four different proofs: the following is the one which is inserted in the Report on Radiant Heat made by M. Biot to the Académie des Sciences; it will soon be seen why I have preferred this proof to the others.

Let us suppose the source of heat, the body, and the thermomultiplier in the proper positions. The plate of the dia-

* Communicated by the Author, through Michael Faraday, Esq., D.C.L., F.R.S.

† Abstracts of these communications have been given in pp. 296–298 of our present volume.—Edit.

thermal substance employed will then be applied against the central opening of the metallic screen: it will immediately transmit a certain quantity of radiant heat, which will penetrate into the cylindrical covering of the pile placed at a distance behind the screen, and directed upon the prolongation of the line drawn from the source to the centre of the opening: the indicating needle of the galvanometer connected with the thermoelectric pile will be set in motion, and will take a greater or a less deviation according to the diathermaneity (*diathermaneïté*) of the substance of which the plate consists. After having noted this arc of deviation, let the pile be removed by degrees from the direction of the immediately transmitted calorific rays, taking care always to hold the opening of its covering turned toward the plate, the distance of which from the pile ought not to vary. We shall then see the deviation of the galvanometer diminish gradually, and be reduced exactly to zero, when the covering of the pile shall have entirely left the conical space occupied by the pencil of emergent heat; which supplies the most complete proof that the heating effect due to the plate itself does not exercise the least perceptible influence on the actual conditions of the apparatus.

To render the force of this demonstration still greater, we may bring the pile several centimetres toward the plate, while we remove it from the immediate direction of the rays. We may also turn the plate upon its vertical axis, and place it opposite the opening of the instrument removed from the calorific cone, without the least deviation being manifested by the galvanometer in either the one case or the other.

It is thus decisively proved by this experiment, that the heat from the source traverses the plate, *preserving its radiant form*; that the calorific rays are propagated beyond the plate *in their original direction only* (*dans le seul sens de leur direction primitive*); and that *all the effect produced*, in the case in which the axis of the pile is in front of the central opening of the screen, is attributable to the action of the radiant heat transmitted immediately by the plate. This mode of demonstration being independent of the nature of the rays, is equally applicable to dark or luminous radiant heat.

Now Mr. Hudson, in removing his thermo-electric pile out of the direction of the calorific rays emitted by a vessel full of hot water, finds that the needle of the galvanometer remains at zero when the opening of the screen is free; but he still observes a very sensible deviation in the case in which the opening is closed with the diaphanous plate. What must we conclude? Evidently, that the circumstances under which

Mr. Hudson experimented were by no means favourable for studying the immediate transmission of radiant caloric through solid bodies; and yet that philosopher cites his results as facts tending to prove that there is no immediate passage of simple heat through that class of bodies. His induction, although presented under a doubtful form, does not appear to me permissible.

Mr. Powell performed in 1825 a very beautiful experiment upon radiant caloric *; it consists in proving that the ratio of calorific absorption of a white surface to that of a black one is not the same for the rays proceeding directly from the source, and for the rays transmitted by a plate of glass. The sources of heat employed by Mr. Powell were an Argand lamp and iron heated to a bright red. I have had occasion more recently to verify this fact, which holds good not only with the glass, but with all diathermal substances, rock-salt excepted. In order to explain this phænomenon, as well as the old experiments of calorific transmission, Mr. Powell admitted that flame and incandescent metals radiate *two kinds* of heat, the *luminous* and the *obscure*, the first of which alone is capable of traversing the glass, whilst the second is entirely absorbed by that substance. He even now thinks that the entire series of my experiments may be explained on this supposition, which he without doubt has modified, in conceding that the interception by solid bodies in general is not a distinctive character of the non-luminous heat, since, in certain cases, it traverses these bodies with the same ease as the most luminous heat. If Mr. Powell alludes to experiments analogous to his own, that is to say, the series of observations which have been made with the pile having one of its faces whitened and the other blacked, I am of his opinion; but I differ from him totally if he admits that the hypothesis of two heats suffices to explain all the facts relative to the transmission. I will limit myself to citing some results which appear to me decisive. If we expose a common plate of glass of one or two millimetres in thickness to the calorific rays of Locatelli's lamp emerging from a black opake glass, then to the immediate radiation of a plate of copper heated to 400° [Cent.?], and finally to the heat emitted from a vessel full of boiling water, we find that its transmission is $\frac{70}{100}$ to $\frac{80}{100}$ of the incident heat in the first case, $\frac{12}{100}$ to $\frac{15}{100}$ in the second, and 0 in the third. Now here the three radiations *consist exclusively of non-luminous heat;* and yet their transmissibility across the same plate is so different, that nearly all the incident rays

[* See Phil. Trans. 1825, or Phil. Mag., First Series, vol. lxv. p. 437 *et seq.*—EDIT.]

of the heat emitted by the lamp pass immediately, while those of the heat emitted by the boiling water are completely absorbed. It is scarcely necessary to add that we should have other transmissions if we took calorific sources of different temperatures from those I have just cited. *There are, then, several kinds of dark heat*, as there undoubtedly exist several kinds also of calorific rays in the heat which ordinarily accompanies light.

Paris, Nov. 15, 1835. MACEDOINE MELLONI.

LXIV. *On the Transformation of Equations.* *By* G. B. JERRARD, *A.B.*

[Continued from page 203.]

IN order to reduce the general equation of the mth degree

$$x^m + A x^{m-1} + B x^{m-2} \ldots + J x^{m-n-1} + K x^{m-n} \ldots + V = 0,$$

to the form

$$y^m + K' y^{m-n} \ldots + V' = 0,$$

in which $A' = 0, \quad B' = 0, \; \ldots \; J' = 0,$

I saw that it would be necessary when $y = P + Qx + Rx^2 \ldots + Lx^\lambda$, to satisfy $(n-1)$ equations, which relatively to P, Q, R, ... L were of 1, 2, 3, ... $(n-1)$ dimensions, and which in the notation of the Researches* would be expressed by

$$\int . (0P + 1Q + 2R \ldots + \lambda L) = 0,$$

$$\int . (0P + 1Q + 2R \ldots + \lambda L^2) = 0,$$

$$\int . (0P + 1Q + 2R \ldots + \lambda L^3) = 0.$$

. . . .

$$\int . (0P + 1Q + 2R \ldots + \lambda L)^{n-1} = 0.$$

No general method had as yet been discovered by mathematicians for determining P, Q, R,... without the aid of an equation of 1, 2, 3,... $(n-1)$ dimensions, when the idea occurred to me, that if, availing myself of the indefinite extent of the series for y, I could detach some of the unknown quantities P, Q, R,... from the rest so as to form a succession of groups, I might possibly be enabled to effect the determination of these quantities by means of equations of 1, 2, 3,... $(n-1)$ dimensions only. But here a great difficulty presented itself. For the purpose of detaching an unknown quantity A from a function of n dimensions relatively

* See Jerrard's Mathematical Researches, p. 41.